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Potential of Biogas Generation from Hybrid Napier Grass

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ABSTRACT

The current investigation concentrated on the production of biogas from Napier grass. The utilization of non-competitive biomass sources for biogas generation via anaerobic digestion is designed for long-term management in biogas production via anaerobic digestion. This study investigates the Napier grass-based biogas production application, which might be used to produce more cost-effective and sustainable biogas. The laboratory-based biogas plant and a biogas plant in operation demonstrated that the laboratory test results were practical and transferrable to practice. The effect of feedstock screening on the biogas yield of Napier grass and cattle slurry was studied in mesophilic CSTR technology digester. Furthermore, the maximum methane level was between 59 percent and 64 percent. Its organic nature makes it an excellent feedstock to produce biogas. Fresh grass was taken after 5 and 6 weeks of plantation, ground in 0.5 to 1 mm diameter size, and fermented in mesophilic CSTR reactors with solid concentrations ranging from 9 percent to 13 percent. At the optimum conditions, biogas yield was 136.4 mL – 142.20 mL CH_4/g VS. The chemical composition of Napier grass (of all three samples) is shown in its approximate and ultimate forms. For a better understanding, grass collection and silage preparation are also displayed. The test was conducted in Ahmedabad, where the Arka BRENStech - Labio was installed (laboratory Biogas Digester) Napier grass (Pennisetum purpureum) was employed as a mono-substrate in all these tests.

KEYWORDS: *Biogas, Napier grass, Mesophilic, Feedstock, Anaerobic Digestion, CSTR,* CH_4

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INTRODUCTION

Coal, petroleum crude oil, and natural gas are all widely used as energy sources, fuels, and chemicals in the world's commodity markets. However, because fossil fuels take millions of years to develop globally, their supplies are finite and prone to depletion when depleted. The advantages of BioCNG, such as lower emissions and long-term sustainability, are widely cited. Biomass is the only other naturally occurring, energy-containing carbon resource known to be substantial enough to be used as a replacement for fossil fuels. Because it can produce electricity, biogas minimizes greenhouse gas emissions while also enhancing protection. The strategy is more environmentally friendly because it employs agricultural and industrial byproducts instead of standard methods and generates power from biomass at a reduced cost despite the high quality of waste digestate produced by anaerobic decomposition; digestate is rarely used in agriculture due to a shortage of air delivery. BioCNG, which is produced from biogas and can be used for both power and distribution, is easy to scale and enables for the decentralized usage of biomass. Methane is one of the principal greenhouse gases influencing the redistribution of solar energy in the Earth's atmosphere. Agriculture, particularly cattle, accounts for around 20 percent of its anthropogenic emissions. The most important quantities of greenhouse gases are emitted during intestinal fermentation of farm animals (about 40 percent) and synthetic fertilizers in crop production (more than 13 percent), and these values are increasing year after year. Greenhouse gases are produced by biological processes as well: agricultural operations produce methane from overall emissions, which are higher. As a result, there has been an increasing awareness in recent years of the need for better waste management measures. Biomass refers to all non-fossil organic materials with chemical energy content. There is also virgin biomass, which includes municipal solid waste, municipal biosolids (sewage), animal waste (manure), forestry and agricultural residues, and certain types of industrial waste. Biomass, unlike fossil fuels, is environmentally favorable because it replaces the energy source quickly. On a global basis, biomass has enormous energy capability. Standing biomass fuel, or renewable, above-ground biomass that may be collected and used as an energy source, is predicted to reach 100 times the world's annual energy consumption. Because they are easy to cultivate, collect, and process, perennial grasses are an ideal source of lignocellulosic biomass for biogas production. In Thailand, several perennial grasses, including para, ruzi, guinea, and Napier grass, can be utilized as biogas feedstock. The most valuable of these grasses is Napier grass, which produces 70-375 tons of biomass per hectare each year. Furthermore, multiple studies have shown that co-digestion produces more biogas than mono-digestion. The goal of this study's overview and concept was to better understand Napier grass mono digestion and its long-term impacts on gas generation.

According to February and Higgins (2010), grasses are more useful than other plant species because of their tolerance and acclimation to temperature and soil. Bajra-Napier hybrid, Napier Bajra hybrids, King grass, Elephant millet, and Cumbu-napier hybrid are all names for hybrid Napier grass. It is found in tropical and subtropical areas of Asia, Africa, southern Europe, and India. It is a tall (200 cm to 300 cm), upright, sturdy, deep-rooted perennial grass resulting from an interspecific hybrid between Pennisetum glaucum and P. purpureum. Because the hybrid is a triploid, it is sterile and does not generate seed. According to Pandey and Roy (2011), among the improved fodder grass species, hybrid Napier grass is a multi-cut perennial grass with profuse tillering and extremely good tonnage all year. It grows well on saline soils, wastelands, bunds, and terraces. It thrives in India's dry and semi-arid regions. According to Singh et al., (2002), it is particularly popular among farmers because of its high yielding capacity, palatability, nutritional value, and adaptability to different climatic and soil conditions. Furthermore, once grown, it provides green feed for at least five years (Rahman and Talukder, 2015). Due to the synthesis of lactic acid, acetic acid, and butyric acid during the fermentation process, hybrid Napier yields silage with a pleasant aroma (Kung and Shaver, 2002) and of high quality (Miyagi et. al, 1993). To alleviate fodder scarcity during the off season, silage made from hybrid Napier can be used. According to the available reviews, scientifically well managed hybrid Napier grass could be an excellent solution for year-round green forage supply of high quality to meet the nutritional fodder requirements of dairy cows.

Hybrid Napier Selection and Nutritional Quality: Variety selection is critical for achieving high yield per unit area under a variety of soil and agro-climatic conditions. According to Das et al., (2000), KKM-1 is better suited to irrigated conditions than other hybrid grass cultivars. Tiwana et al. (2004) discovered that the hybrid Napier variety PBN-233 yielded more green fodder and dry matter. CO-3 hybrid Napier type produced the highest green forage and dry matter output in various locales (Premaratne and Premlal, 2006; Chellamuthu et al., 2011; Raj and palled, 2014). Antony and George (2014) discovered that nutritional parameters such as crude protein, crude fiber, total ash, and mineral content change significantly between Hybrid Napier cultivars. According to Sarmini and Premratne (2017), hybrid Napier produced much more dry matter (17 percent), ether extract (4.34 percent), and ash (16.06 percent) than sorghum. In addition, it produced much more crude protein (10.92 percent) than maize (7.35 percent). Hybrid Napier outperforms other perennial grasses in both quantitative and qualitative terms. According to Senthil et al. (2016), hybrid Napier includes low ADF and NDF, indicating less fiber and higher digestibility for livestock. Under heavy rainfall conditions, Kadam et al., (2016) from Goregaon (Maharashtra) showed that hybrid Napier cultivars CO-4, DHN-6, and CO-3 produce high crude protein content (11.36, 10.63, and 9.86 percent, respectively).

Yield of Hybrid Napier Genotypes in India's Different Zones:

Table-1

Area recommended for Cultivation	Genotype	Yield (t/ha)
South Zone	CO 1	280 – 320
South Zone	CO 2	340 – 370
South Zone	CO 3	180 – 230
South – Districts of Tamil Nadu	KKM 1	240 – 270
South – Andhra Pradesh, Karnataka & Tamil Nadu	APBN 1	200 – 250
Kerala	Saguna	250 – 280
Karnataka	Sampoorna DHN 6	140 – 175
Punjab	PBN 83	150 – 190

Punjab	PBN 233	360 – 400
Maharashtra	Yashwant RBN 9	150 – 175
North & Central Zone	Swetika Hybrid Napier 3	80 -100
Whole of India and Tropics	NB 21	140 – 180
Whole of India and Tropics	Pusa Giant Napier Grass	140 -180

Management of Harvesting or Cutting - Plan:
Because hybrid Napier grass is a perennial forage grass, cutting it at the proper stage is critical to obtaining better quality and yield. According to Wangchuk et al. (2015), total dry matter plant-1 was higher during a 80-day cutting interval compared to a 45-day cutting interval, but crude protein content was the opposite. Furthermore, the cutting interval has a considerable impact on the total dry matter, plant height, number of tillers, leaves, and crude protein content of the plant. It was discovered that if the Napier grass is harvested at 45 days, the nutrients and parameters operate properly.

Considering a daily requirement of 50 tonnes of Napier grass.

Table – 2

Napier grass (in tonnes per day)	Per Month (tonnes)	Per Year (tonnes)
50	1500	18250

For growth and harvesting of the required Napier grass at an average of 140 tonnes to 150 tonnes per acre in 5 cutting crops each year, 140 acres to 150 acres are required. Each cutting cycle can produce 520 tonnes to 540 tonnes per week and can be repeated 52 times in a batch of 20 acres. Overall land may be divided into 20 acres batches and cultivated with an average of 520 tonnes per batch, and this batch will be continued after 45 days, and the same land can be used for another 5 cycles. On an average, the cost of production in the first year may range from INR Rs. 800 to 900 per tonne of Napier grass, but if we consider the entire 5 year cutting schedule, the same cost drops to almost INR Rs. 450 to Rs. 500 per tonne, and on an average for 5 years cutting cycle, the cost may range between Rs 550 to Rs 650 per tonne of Napier grass per crop cycle in 5 years.

Napier Grass Proximate, Ultimate, and Chemical Composition (3 samples collected to generate biogas for the study) is given in the below table.

Table – 3

Property	Sample 1	Sample 2	Sample 3
pH	4.75	4.80	4.85
Proximate Analysis (wt.%)			
Moisture	67.80	71.50	70.00
Ash	2.50	2.90	2.60
Ultimate Analysis (wt. %)			
Carbon	43.90	44.20	44.00
Hydrogen	5.80	6.00	5.90
Nitrogen	2.00	2.00	1.90
Oxygen	42.90	43.90	43.50
Sulfur	0.05	0.06	0.05

Samples were taken from three distinct places in India.

Specifications of Experimental parameters and Biogas Measurements:

Table – 4

Parameters	Equipment or Method
Napier Grass particle size	1.00 mm
Daily substrate	**10% solids fed to the digester
Digester technology	CSTR – Labio *(laboratory digester of Arka Brenstech Private Limited)*
Volume of the Digester	50 ltr
Used volume of the Digester	40 ltr
Gas Meter	Wet type gas flow meter (1 no)
Methane	ASTM D 1945
Carbon dioxide	ASTM D 1945 – 03
Hydrogen	ASTM D 1945 – 03
Hydrogen Sulfide	ASTM D 5504 – 01
Oxygen	ASTM D 1945
Sulfur	ASTM D 6667 -04

Biogas Production from the samples in CSTR Laboratory Digester:

Table – 5

Details	Sample 1	Sample 2	Sample 3
Moisture Content %	67.80	71.50	70.00
Total Solid Content %	32.20	28.50	30.00
Volatile Solids %	85%	84%	85%
Biogas Production l/kg VS	560	520	510
Methane %	60	59	59

Arka Brenstech Private Limited Laboratory Digester

Result and Discussion:

After completing the second cycle from the date of commissioning, biogas output was measured, and samples were gathered from various regions. A total of three different samples were studied, and the results are shown in Table – 5.

It was discovered that the samples obtained varied by around 4 percent to 5 percent in terms of total solid content (percent), which had a direct effect on biogas generation based on total solid content. Because the gathered Napier grass was fresh, the results were immediate but the Napier grass was collected monthly for the experimental purpose. However, the gas production found in "Sample 1" was 152 m^3 per tonne of fresh Napier grass with 32 percent total solid content, whereas the other two samples were between 124 m^3 to 130 m^3 per tonne of fresh raw Napier grass with 28.50 percent and 30 percent total solid content. In all three samples, the methane level in the raw biogas ranged between 59 percent and 60 percent. The experiment lasted 180 days, which is comparable to 6 cycles when 30 days is used as the retention time. However, with increased retention time gas production may show some increase, but one must consider practicalities while contemplating higher retention time.

The raw biogas output of the Napier grass with a solid concentration of 28 percent to 32 percent was thoroughly researched, but the feed to the digester was kept at 10 percent solid content. However, the trials conducted in conjunction with the previous experiments clearly shown that the biogas output dropped as the total solid input to the digester increased. It also had some influence on the methane proportion when the overall solid content in the digester feed increased. When the overall solid content of the digester was increased, the alkalinity within the digestion increased as well.

Conclusion:

The preceding study investigated the viability of Napier grass as a feedstock for biogas production. Napier grass is a fast-growing, high-yielding crop that is also very nutritive, making it excellent for use as an energy crop for biogas production. Napier grass may be digested without any additional substrate; however, after the sixth cycle, gas production began to decline, and Napier grass required either cow manure or chicken manure (rich in nitrogen) substrate to provide a steady level of biogas output in the long run. The results showed that Napier grass contains a high concentration of organic compounds, which are appropriate for use in the anaerobic digestion process to sustain microbial life and convert nutrients into biogas. The methane proportion was discovered to be around 60 percent, which can be increased with co-digestion. This also implies that it is quite conceivable to achieve stable operation using Napier grass as a substrate for biogas production with co-digestion, as well as any nitrogen-rich substrate in the event of bigger plants, to ensure a constant C:N ratio within the digester. The digestate produced by biogas digestion is a good source of fertilizer, as well as being advantageous to environmental safety and management. It was determined that Napier grass, as an energy crop, has the potential to be an alternative energy supply.

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